Dryland Saline Seep Control

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INTRODUCTION

Dryland saline seepage is a major soil degradation problem in Alberta. 1.6 million acres of dryland are affected by secondary salinity. The problem is caused when water enters the soil profile, moves beyond the root zone, and forms a recharge area. The recharged water flows through the soil, picks up salt and causes ground water levels to rise in discharge areas. Subsequently, the ground water surfaces in the seep and evaporates leaving a salt residue behind. Over time the salt level in the saline seeps increases to the point where plant growth is restricted. The key to controlling dryland salinity is the appropriate management of surface and soil water supplies. Encouraging maximum use of water by plants is one option, while managing surface and subsurface water is an other.

NATURE OF SALINE SEEPAGE

Preface

Saline seepage in dryland conditions is defined as: the presence of saline water on an intermittent or continuous basis, at or near the soil surface, downslope from a recharge area. The increased concentration of soluble salts in the root zone reduces or eliminates crop growth in the affected area. Saline seeps can be differentiated from other saline soil conditions by their recent origin, saturated root zone and shallow water table (Brown).

Saline seeps are characterized by a high water table, an accumulation of salt, the presence of salt tolerant vegetation and in some cases by hydraulic discharge. The high water table makes the site wet and inaccessible to equipment. Perennial crops are easiest to manage under these conditions.

Salts accumulate throughout the upper portion of the soil profile. The salt content of soil can be estimated from an electrical conductivity (EC) measurement, expressed in deci-siemens/meter (dS/m), as made on a saturated soil paste extract (Table 1). The predominant salts in our saline soils are sodium, calcium and magnesium sulfates. The sodium adsorption ratio (SAR) is used as a measure of the effect of sodium in the soil. Soils high in sodium (SAR 13) often exhibit poor tilth and low permeability. Most of our saline soils are sodic.

TABLE 1.
Classification of Severity of Soil Salinity in EC Units (dS/m)

Soil Depth (cm)	Non Saline	Weak	Mod.	Strong	Very Strong
0 - 60	2	2 - 4	4 - 8	8 - 16	16
60 - 120	4	4 - 8	8 - 16	16 - 24	24

The high concentration of salt in a seep prevents the uptake of water and essential nutrients by plant roots. Some native plants are more tolerant to salinity and can serve as a useful indicator of salinity. Red samphire (*Salicornia rubra*) and sea blite (*Suaeda depressa*) are very salt tolerant. Wild barley (*Hordeum jubatum*) is also salt tolerant as well as being able to withstand saturated conditions. Kochia (*Kochia scoparia*) survives at salinity levels of 8 dS/m.

Potential saline seeps can be identified many years before they become severely affected. The early signs of seep development are:

- A flush of crop growth, combined with excellent yields
- Increasing wetness, causing inaccessibility
- Lush growth of weeds, particularly Kochia in the fall amidst a mature crop

These initial signs of a saline seep are followed by more obvious signs as the saline seep matures. These are:

- Sparse germination of crop and weeds
- Decreasing crop yields
- Invasion by salt tolerant weeds and
- Salt accumulations on the soil surface

The increase in size and severity of the affected area at each stage of development depends on the type of saline seep.

The salinization of shallow groundwater and surface water is a concern. Evaporation over the summer can concentrate saline surface water supplies (ponds, sloughs, dugouts, etc.) to toxic levels. Livestock consuming saline water can contract bovine polio, resulting in lost productivity and even death. Wildlife are also affected by reduced water quality. Lakes with high salinity levels will not support fish and are avoided by water fowl.

Extent Of The Problem

1.6 million acres of dryland in Alberta are affected by secondary salinity with an average crop yield reduction of 25 per cent. Soil salinity on farmer's fields ranges from very strong to weak. In a saline seep, the salt concentration is often highest in the centre, and decreases towards the edges. This is indicated by the concentric rings of vegetation of variable salt tolerance. In southern Alberta, areas around Warner, Vulcan, Lethbridge,

Three Hills and Drumheller are most affected. In central Alberta Provost, Mundare and Vegreville areas are also affected. The problem is present in other provinces and states within the northwestern Great Plains region. The extent and severity of the dryland saline seep problem is increasing at a rate of approximately five per cent per year, but grows more quickly following a few wet years.

DRYLAND SALINE SEEPAGE FORMATION

Preface

Long before the first European settlement of Alberta, many areas contained saline seeps which formed under natural conditions. However, during the last few decades the extent and degree of salinity have shown a rapid increase. This increase is linked to agricultural practices, specifically summerfallowing.

Recharge-Discharge Mechanism

Saline seep development involves one or more recharge areas. In the recharge area, water in excess of the water-holding capacity of the soil moves below the root zone and forms a groundwater gradient (Figure 1). The groundwater flows to a discharge area downslope. Flow occurs most often over a shallow, less permeable soil layer. In Alberta, most of the groundwater flow systems are local in nature. This means the water from recharge areas are within one kilometer of discharge areas. Intermediate flow systems are characterized by flows longer than one kilometer. Regional flow systems extend over several kilometers between recharge and discharge. The groundwater travelling to the discharge area dissolves and moves water soluble salt present in the soil. The flow of groundwater causes the water table in the discharge area to rise until it is within the capillary zone. Once in the capillary zone, cohesive and adhesive forces act like the wick in a kerosene lamp, to pull the saline water to the surface. Evaporation of the water results in salt accumulation.

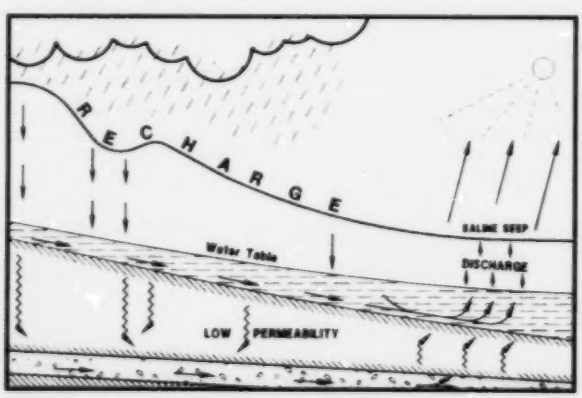

Figure 1.
A typical recharge-discharge mechanism.

Most of the upslope region of a discharge area is considered a potential recharge area. Dominant recharge areas are those portions of a field that contribute more to deep percolation than other parts of the field. Dominant recharge areas are characterized by:

- Water and snow accumulation on the surface, (depressions, drainage courses, snowfences, borrow pits and shelterbelts)
- Soil profiles with low potential for additional moisture storage, such as those with coarse textures, shallow bedrock (less than two meters) and
- Areas of shallow water tables (Figure 1)

Preventative controls are concentrated on the dominant recharge areas, because maximum impact can be obtained with a minimum amount of expense, time and change in cultural practices.

Types of Saline Seeps

There are a number of different types of dryland saline seeps, all of which are characterized by the way they are formed. In Alberta at least six different types are recognized:

Slope-change saline seep (Brown)
Figure 1 depicts the slope-change seep mechanism. Grcundwater flows through the root zone to a less permeable layer and then moves downslope. When the slope decreases at the bottom of the hill, the water movement slows down, the water table rises which results in a saline seep. The growth of the saline seep is mainly downslope. These saline seeps are common in southern Alberta.

Texture-change saline seep (Brown)
These saline seeps occur where lateral groundwater flow is blocked by less permeable, finer textured soils (Figure 2). The less permeable surficial material blocks the horizontal movement of water. This causes the water table to rise. These saline seeps often occur on the side of a hill.

Geologic outcrop saline seep (Brown)
These saline seeps occur where a permeable water bearing layer, such as a coal seam, or a sandstone or fractured bedrock layer protrudes at or near the surface (Figure 3). These seeps sometimes occur as a chain, in a straight line for several kilometers. The associated groundwater flow is sometimes intermediate in nature,

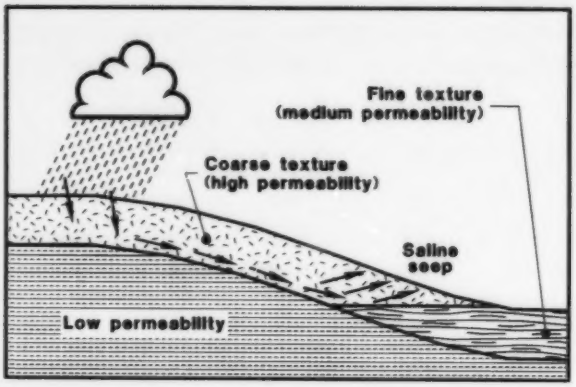

Figure 2.
Texture change saline seep

which means the recharge area is a few kilometers from the discharge area and covers several sections of land.

Hydraulic discharge
Water in a hydraulic discharge seep rises to the surface from either a bedrock or overburden aquifer. These aquifers are usually pressurized, because of elevation differences, more fractures or courser material like sands and gravels (Figure 4). The aquifer is said to exist under artesian conditions and may produce a flowing well spring, or soap hole, if the pressure is great enough to push a flow of water to the soil surface. The groundwater flows feeding hydraulic discharge types are generally of an intermediate or regional nature.

Bathtub ring seep
This seep is a narrow ring of salt immediately adjacent to the standing water in a slough (Photo 1). The recharge is from the slough water. It flows laterally into the soil, building a

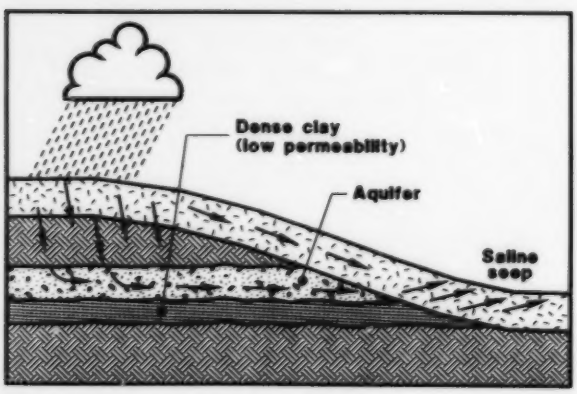

Figure 3.
Geologic outcrop saline seep

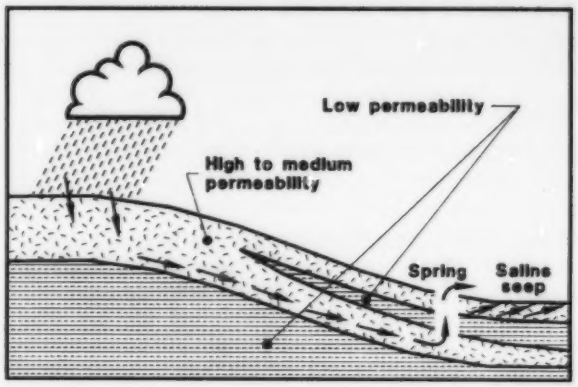

Figure 4.
Hydraulic discharge seep

high water table below the slough and at its edge. Water then moves to the surface by capillary action creating a salt ring around the slough. These saline seeps are quite prominent in central Alberta.

Depression bottom seep
These seeps result from a water table buildup in a depressional area, generally on top of shallow bedrock. They occur in valley bottoms, slough bottoms and eroded coulee heads. Most coulees in southern Alberta, such as Etzikom and Verdigris coulees, are salinized. These areas have limited drainage.

Photo 1.
Bathtub ring seep

SOURCES OF SALTS AND EXCESS WATER

Preface

Saline seepage is mainly a water management problem in the recharge area resulting from excess soil moisture percolating beyond the root zone of annual crops. Once the soil moisture is below the rooting zone it is out of their reach. The excess groundwater seems inconsistent with the common shortage of plant available water on the prairies.

Source of Salts

Alberta soils contain high levels of water soluble salts. The salts in the soils result from the oxidation of minerals in the upper, weathered glacial till. The sulfate and nitrate contents are many times higher in the surface soil as compared to the unweathered deeper material. These salts rarely become a problem in the location where they are formed, until they accumulate in the discharge area.

Sources of Excess Water

Agricultural practices, such as summerfallowing, have accelerated the salinization process by increasing the amount of water that percolates beyond the root zone. This and other contributors raise the water table in the discharge area and bring dissolved salts to the soil surface. A more detailed description of the factors are as follows:

Water and snow accumulation – Accumulation of water and snow may aggravate the saline seep problem. Natural ponds, roadways, railways, borrow pits, snow fences, buildings, tall weeds and fence lines can trap water and snow. Following snowmelt, most of this water infiltrates into the soil near the drift. During the unusually wet spring of 1975 in northwestern Montana, all depressions became filled with runoff. As a result, the water table in the region rose from 90 to 180 cm (35 - 70 in.). Good snow management distributes the snow in the fields, helping to collect moisture in the root zone for crop use. Maintaining good surface drainage prevents an accumulation of runoff water in undesired areas.

Summerfallow – In a summerfallow field the root zone beomes filled with water. Excess water moves down and out of the root zone raising water tables. Research shows that 75 per cent of the precipitation that falls during a 21 months fallow period is lost by runoff, evaporation and recharge. This means that of the 528 mm (21 in.) precipitation in Lethbridge only 131 mm (5 in.) is stored for crop production (Table 2).

TABLE 2 .
Amount of precipitation stored and lost in 150 cm of topsoil under summerfallow, Lethbridge

	Harvest to spring	Fallow season	Fall to spring	Total
Precip. (mm)	183	180	165	528
Stored (mm)	86	15	30	131
Lost %	53	91	81	75

Sandy Soil – The average overwinter precipitation often fills a sandy root zone. According to Figure 5 a sandy loam soil only holds 80 mm (3 in.) of available water per meter (3.3 ft) of soil. Recharge will likely occur in most sandy soils during the very first spring of the fallow period.

High precipitation periods – During periods of high annual and seasonal precipitation, water tables show dramatic rises. This results in an increased flow toward saline seeps. Recharge often occurs during May and June, the months of peak precipitation. During a series of wet years, the water table becomes progressively higher each year. Water tables across the prairies rise rapidly to maximum levels in the spring after the frost has left the soil, or after major rains. When the water table is within about 180 cm (6 in.) of the surface in a clay loam soil, capillary action lifts the water to the surface. Surface soil salinity is most obvious in early spring

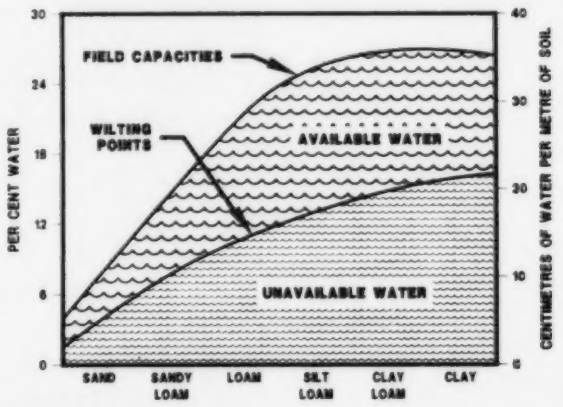

Figure 5 .
Water holding capacities of various soils

when the water table is high. Water tables drop over the summer and reach their lowest level in late fall and winter.

Irrigation canal seepage – Dryland is often interspersed with irrigated land in southern Alberta. Seepage from irrigation supply canals causes a considerable amount of salinization on both dryland and irrigated land.

Subsoil moisture – Below the root zone, an abundance of moisture is present in the subsoil at most prairie landscape locations. In some places and at certain times the subsoil is saturated. A soil moisture survey showed 74.5 cm (29 in.) more moisture in a six meter (20 ft) profile of a dark brown soil under cultivation than was found in adjacent native grassland (Table 3). The high subsoil moisture content aggrevates the effects of spring melt, high precipitation periods and ponding of water.

TABLE 3.
Moisture status of cultivated and non cultivated Dark Brown soil.

Depth (m)	Cultivated %	Non-cultivated %	Difference (cm)
0 - 1.2	24.3	12.5	21.3
1.2 - 2.4	23.2	10.8	22.2
2.4 - 3.6	19.6	11.7	14.4
3.6 - 4.8	16.4	11.5	8.9
4.8 - 6.0	16.2	12.0	7.7
Total			74.5

Hydraulic Discharge – Water, trapped in gravel and sand layers, coal seams, sandstone layers and fractured bedrock often has a high hydraulic head. The hydraulic discharge seeps can express themselves as springs, soapholes or flowing wells.

DRYLAND SALINITY INVESTIGATION SERVICE

Preface

Saline seeps vary as do the controls. Controls are generally costly as well as risky. It is recommended an investigation be carried out on a saline seep before controls are implemented.

A Dryland Salinity Investigation Service is offered by Alberta Agriculture. The main purpose of such an investigation is to identify the type of saline seep and to locate the dominant recharge areas. Control measures can then be recommended to get effective results. Application for the service can be made with the local district agriculturist, agricultural fieldman, regional soil specialist or soil/crop specialist. The investigation consists of four parts, these are:

Collecting Existing Information

Aerial (1:10,000) scale photographs, hydrogeological maps, surface and bedrock geology maps and topographic maps are obtained for each site. The Groundwater Resources Information Service, Alberta Environment supplies additional information on geology and groundwater chemistry. Alberta First Call is notified to locate utility lines.

Field Inspection

During field inspections, the farmer is asked the age, rate and direction of growth of the saline seep, as well as the cropping practices used on the upslope area. This information helps to identify the type of saline seep and the possible location of the dominant recharge area. A soil moisture probe is a good instrument for locating recharge areas. Wherever the probe can be pushed by hand over one meter into the soil, it indicates an area of potential recharge. Electromagnetic conductivity meters (EM38 and EM31) are used to map the relative soil salinity of a field (Photo 2). The salinity survey helps to decide where to drill, and minimizes the amount of drilling required. It also assists in monitoring the seeps for effective reclamation after the controls are implemented.

Drilling

A select number of test holes are drilled to identify potential problem sites, to collect soil samples for chemical analysis and to install instrumentation for monitoring

Photo 2.
Electromagnetic conductivity meter EM-38

Photo 3.
Auger-type drilling unit

groundwater. Truck mounted auger-type drilling units are used (Photo 3). These units can be outfitted with air compressors to drill in hard bedrock. The soils are carefully logged for texture, parent material, wetness, firmness, color and other factors. PVC pipe is used for water table observation wells or piezometers.

Piezometers utilize "Rice" well screens on the bottom (Figure 6). They are usually placed in an aquifer. A sand pack is constructed around the screen and a watertight bentonite (driller's mud) plug is installed above the sandpack. Piezometers are placed in groups of two or more at different depths. These instruments indicate the hydraulic head of water in a pressurized formation by its level in the pipe. Sometimes the pressure is large and causes artesion conditions.

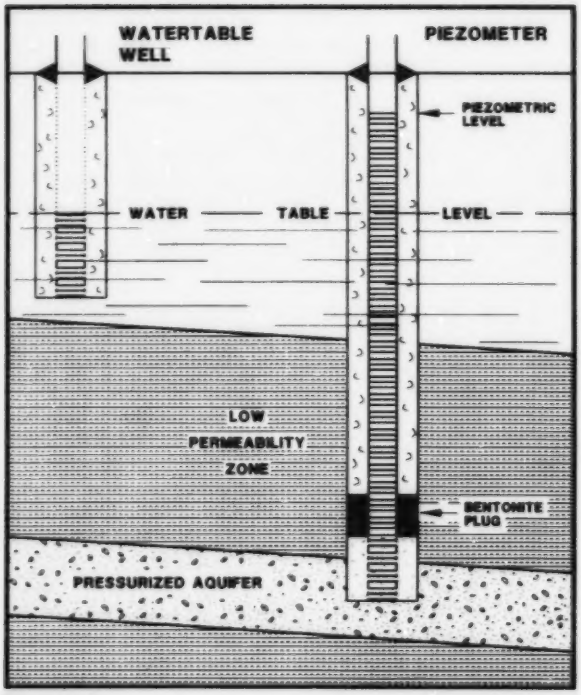

Figure 6.
Water table well and piezometer.

As drilling is expensive, each drilling site is carefully chosen to determine the following characteristics:

- Location and extent of shallow water tables
- Presence of saturated sand and gravel layers
- Water table gradients
- The hydraulic head of groundwater aquifers
- Upslope areas of shallow bedrock or sandy surficial materials and
- Finer textured material downslope of a saline seep, that may cause a blockage to a shallow groundwater flow

Farmers observing the drilling operation can gain insight into their specific soil problems.

Monitoring

Water table well levels usually require 48 hours to stabilize after their installation. Piezometers, on the other hand, may require several days or even weeks to stabilize. Water table wells and piezometer levels are especially monitored during the spring. Shallow water table levels can be measured using a small diameter plastic hose about six meters in length. While blowing through the hose, air bubbles can be heard when the water table is reached. The depth is noted by markings on the hose (Photo 4). A plopper can also be used to monitor levels. A plopper is a marked string with a fishing float attached. The float is lowered down the well until it reaches the groundwater. More sophisticated monitoring instruments like electronic depth sounders are also available. Monitoring should continue after control measurers are adopted in order to determine the effectiveness of these measurers.

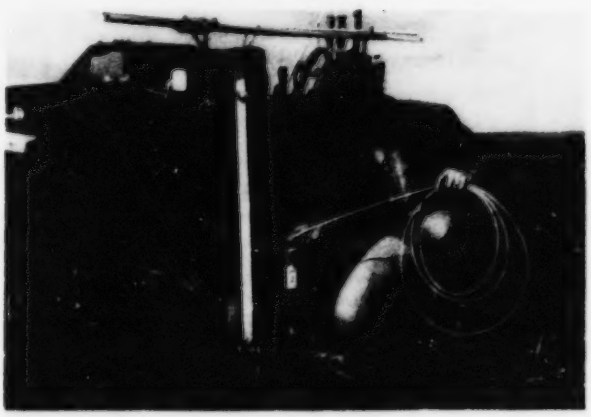

Photo 4.
Monitoring water table wells

VEGETATIVE AND MECHANICAL CONTROLS

Preface

A number of dryland salinity controls have proven to be successful. The distinctiveness of each saline area and its recharge area requires a different control or combination of controls for each site.

Recharge Controls

Controls applied in the recharge area prevent salinity. Preventing the accumulation and deep percolation of water in the recharge area is the preferred measure of control. This prevents the salinization process before it becomes a problem.

Surface water management – Utilizing the surface water in intermittent natural and man-made ponds in the recharge area is an effective, important and often inexpensive method of dryland saline seep control. For example, an open trench or buried pipe can be used to consolidate the water in a water body downslope of the saline seep. The inlet of the buried pipe in the pond should be about half a meter below ground level and connected to the surface by a gravel pack or upright standing pipe. Using and/or removing upslope ponded water prevents recharge. This ponded water is relatively salt free and therefore excellent for use for other purposes. Since the problem ponds occur in upland positions, they generally lend themselves for gravity outlets.

High moisture use crops – Perennials, forages and especially alfalfa, have a longer growing season, use more water per unit depth of soil and from a greater depth than annual crops (Figure 7). Deep-rooted perennials also use the current annual precipitation. As a result they prevent the buildup of groundwater, lower the water table, and dry out the subsoil (Figure 8). In addition, forages increase the organic matter content of a soil, improve structure and reduce erodibility by wind and water. Legumes, through nitrogen fixation, also increase the fertility of the soil.

Deep-rooted forages, like alfalfa, should be planted on all dominant recharge areas identified by the dryland salinity investigation service. Recharge areas are about three to ten times the size of the saline seep. A very common dominant recharge area is the strip of land with a high water table immediately upslope of the saline seep. On average, it takes about five years of growing

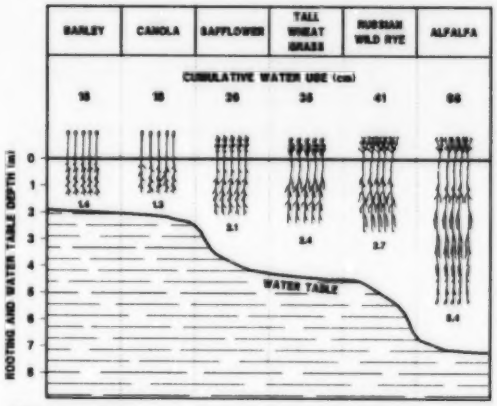

Figure 7.
Cumulative water use (C.W.U.) and rooting depth of crops over a four year period (Brown)

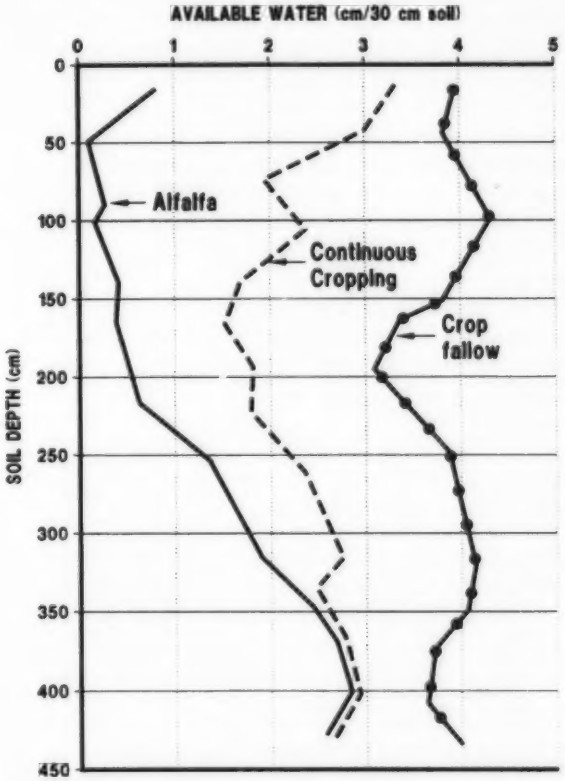

Figure 8.
Available soil moisture water under various crop systems (Brown)

alfalfa to lower the water table in the saline seep. Once the water tables here are lowered to an acceptable level the recharge area may be annual cropped again. There is a need for long-term, on-going cropping rotation which include several years of alfalfa each time. The water table levels must be monitored regularly in order to see if, and by how much they rise again.

Establishing forages requires special management. Phosphorous fertilizer is particularly important and should be deep banded prior to seeding alfalfa. A soil fertility analysis will provide exact recommendations. A two tons per acre dryland alfalfa crop requires 9 kilograms (20 pounds) phosphorus per acre. Phosphorus is very immobile in the soil and should be applied in one large application prior to the establishment of the alfalfa. A five year stand of alfalfa will require 45 kilograms (100 pounds) of phosphorus per acre to meet target yields. Alfalfa is a legume and should be inoculated with the proper bacteria to allow the plant to fix atmospheric nitrogen. Nitrogen fertilizer should not be used on a stand that has been properly inoculated because it hampers the plants ability to use atmospheric nitrogen by reducing nodulation. In Alberta most other nutrients are available in the soil and need not be applied. However, a soil test should always be done to insure proper levels of all nutrients are being met.

The best time for planting alfalfa is in the spring when growing conditions are ideal. Other times will give satisfactory results if the proper conditions are met. The seed bed should be firm and mellow. Seeding should be as shallow as possible. The hoe drill has given the most consistant results because it has even depth control and good packing. Disk drills work satisfactory if depthbands are used. Surface seeders and dribblers have given inconsistant results with areas of poor germination. Nurse crops should only be planted to prevent wind erosion and should be seeded at half the normal seeding rate. Consult the Forage Manual for specific recommendations on varieties, seeding rates and specific other management techniques.

> **Flex Cropping** – The widespread use of the two-year crop-fallow rotation on the prairies has contributed significantly to the saline seep problem. Flex cropping is recommended for the dominant recharge areas where bedrock is too shallow for forages to be effective.

Research done in Montana has shown flexible cropping results in significantly lower amounts of soil moisture than a two-year crop-fallow rotation (Figure 8). Spring soil moisture is a factor which should be considered when recropping. A minimum of 16 to 22 cm (6 - 9 in.) of available water from stored soil moisture and rainfall is required to successfully recrop. Stored water in the rootzone should supply at least 10 cm (4 in.) of this amount (Figure 9). Recropping is done in the years when spring soil moisture is adequate.

Soil moisture content can be measured with the Brown probe (Photo 5). The depth the probe can be pushed by hand in the soil indicates the depth of wet soil. A clay loam soil and a sandy soil when they are wet to a depth

Photo 5.
"Brown" soil moisture probe

of 70 and 150 cm (27 and 60 in.), respectively hold 10 cm (4 in.) of plant available water.

Snow management may improve stored soil moisture for recropping purposes. To supplement spring soil moisture, standing stubble is used to trap and evenly distribute snow over the field. Stubble barriers and alternate stubble heights trap even more snow than normal stubble (Table 4). Stubble barriers are obtained by attaching a stubble deflector to the swather header (Photo 6). Stubble barriers collected an extra 0.2 to 6.2 cm (.01-2.5 in.) of water compared to bare soil at Swift Current. Inside the chinook belt these gains would be lower. Water gains from snow trapping approximate those of 12 months of fallow.

TABLE 4.
Water gains from snow management through various cultural practices in comparison to bare soil

	Water Gains (cm)
At Swift Current	
– Stubble barriers (53 cm tall)	3.0 - 6.2
– Alternate stubble heights (32 & 15 cm tall)	0.2 - 4.7
At Lethbridge	
– Zero-tillage	2.8
– Reduced tillage	1.2

Fertilizer, especially nitrogen is required to obtain good yields when recropping (Figure 9). Available nitrogen normally increases during the fallow year as organic matter breaks down. This accumulation of nitrogen does not occur during recropping because of crop demands. With increased amounts of plant-available water, higher fertilizer levels are required in order to obtain optimum

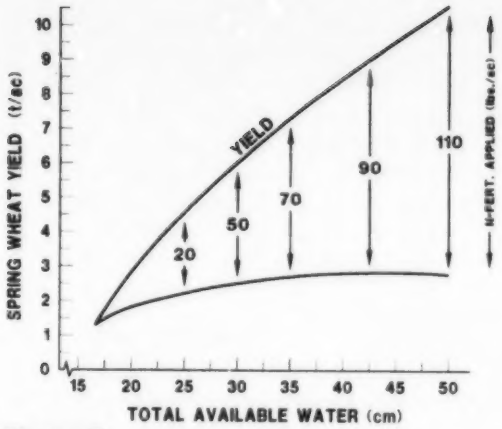

Figure 9.
Effect of spring plant available water and fertilizers on crop yields (Black)

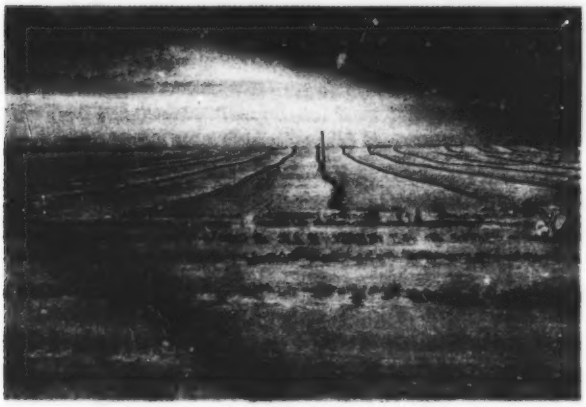

Photo 6.
Stubble barriers trapping snow

yields. To determine fertilizer requirements, tests are recommended.

Alternate crops can be used for recropping instead of spring cereals. Winter wheat, with its 150 cm (5 ft) rooting system and early spring growth, uses more moisture and from deeper in the soil than spring wheat. Winter wheat is often planted in standing stubble, protecting it from the desiccating chinook wind, while collecting extra amounts of snow in the winter. Fall seeded cereals like winter wheat exhibit greater weed competition than spring seeded cereals, but often serve as host to the same insect and disease problems as spring wheat. Winter wheat is very susceptible to wheat streak mosaic. For best results seed winter wheat between the first and 15th of September.

Non-cereal crops which can be used in rotations are safflower, canola (Photo 7), sunflower, sweet-clover and others. Safflower and sunflower both have taproots and higher moisture use than spring cereals. They also

Photo 7.
Canola field

root deeper into the soil profile (Figure 7). They are cash crops, marketed outside the Canadian Wheat Board. Sweet-clover, a biennial, if plowed down in the second year, improves the soil by adding organic matter and nitrogen.

Discharge Controls

Control of salinity in the discharge area should be combined with proper management controls in the recharge site. Some of the more effective discharge controls are:

Perennial vegetation – At the same time as the upslope recharge area is planted to a perennial crop like alfalfa, the saline seep itself should be seeded to a salt tolerant perennial crop. Grasses are quite salt tolerant and are the preferable choice (Table 5). Plants are most affected by salinity in the early stages of growth, from germination to the four leaf stage. Saline seeps are often the wettest and most saline in the spring. Grasses can be seeded in the fall when the saline seeps are dry and accessible. Seeding rates for saline seeps, especially when planted in the fall, are usually double those of non-saline areas. The Alberta Forage Manual gives an overview of the characteristics of the grasses available in Alberta as well as some specific management requirements.

Saline areas should not be left bare for an extended period of time. Even weeds, such as Kochia, are preferable to a bare soil. Like grasses, Kochia will lower the water table and stabilize the affected area. Kochia, harvested at the midbloom stage, yields an acceptable forage and is suitable to be mixed with other quality forages. Care should be exercised in feeding livestock the crops from saline seeps since high sulfate levels are common.

TABLE 5 Salt tolerance of various types of plants (McKenzie)

Tolerance EC(dS/m)	Field Crops	Forages	Vegetables and Fruits	Trees, shrubs and ornamentals
Very high 20 16		Beardless wildrye Puccinellia distans Levonns alkaligrass Alkali sucatan Altai wildrye		
High 6	Kochia Sugar beets 6-row barley Safflower Sunflower 2-row barley Fall rye Winter wheat Spring wheat	Tall wheatgrass Russian wildrye Slender wheat grass Birdsfoot trefoil Sweetclover Alfalfa Bromegrass	 Garden beets Asparagus Spinanch	Siberian salt tree Sea buckthorn Silver buffaloberry Hawthorn Russian olive American elm Siberian elm Villosa lilac Laurel leaf willow
Moderate 4	Oats Yellow mustard Flax Canola Corn	Crested wheat grass Intermediate wheat grass Meadow fescue Reed canary grass	Tomatoes Broccoli Cabbage Sweet corn Potatoes	Spreading juniper Poplar Ponderosa pine Apple Mountain ash Common lilac Siberian crab apple Manitoba maple Viburnum
Low 0	 Peas Field beans	Timothy White dutch clover Red top Alsike clover Red clover	 Carrots Onions Strawberry Peas Beans	Colorado blue spruce Rose Douglas fir Balsam fir Cottonwood Aspen, Birch Raspberry Black walnut, Dog-wood Little-leaved linden Winged enonymus Spires Larch

* Electrical Conductivity

Subsurface drainage – The purpose of subsurface drainage is to remove water and desalinize the root zone of the saline seep. These objectives are difficult to attain. Alberta soils usually have a low permeability, (approximately 0.25 cm/hr). The warm, dry climate encourages capillary rise and there is normally inadequate precipitation to leach salts downward in dryland. Nevertheless, with proper investigation, design, installation and management, subsurface drainage can be used satisfactorily in some cases.

A licence is required from Alberta Environment for any drainage project which diverts water onto another quarter section of land. Licensing prevents both the unwanted diversion of water and the discharge of large quantities of highly saline drainage water into streams and reservoirs.

A grid-relief system is generally used for dryland subsurface drainage. This design has several parallel lines of perforated corrugated plastic tubing placed at prescribed spacings throughout a field. Generally, perforated corrugated plastic tubing 100 mm (4 in.) in diameter is used for farmland drainage. The minimum permissible grade for unfiltered pipe is 0.2 per cent. Tubing can be installed with a plow or chain trencher (Photo 8) outfitted with a laserplane automatic depth control.

On dryland soils in southern Alberta, the subsurface drainage systems are designed to maintain water table levels deeper than 180 cm (6 ft) below the surface. For central and northern Alberta, the critical water table depth is somewhat shallower.

Careful installation of the pipe should result in a minimum loss of soil permeability around the tile. To attain this the following practices are suggested:

Photo 8.
Drain trencher with laser plane grade control

- Install during the fall or late summer, when the water table is low and the soil is dry
- Use trenchers in dry, hard, and layered soils and plows in wet soils
- Backfill the trench immediately and completely when a trencher has been used and
- Pre-rip hard and frozen soils. This eliminates a considerable amount of compaction caused during installation

Proper management of the installation of the drainage tile will aid in the success of the reclamation. Average amounts of precipitation are usually not adequate for leaching salts from dryland saline seeps. To increase available leaching water for a subsurface drained saline-seep:

- Trap snow on the site and
- Divert and accumulate runoff onto the site

Chemical amendments – Gypsum has been tried experimentally to reclaim saline soils. The calcium of the gypsum (calcium sulfate) replaces the sodium on the soil complex and thus reduces the sodic condition of the soil. Because of the low solubility of gypsum, its success has been very limited, especially in soils with an electrical conductivity over 2 dS/m.

Applications of 13 tonnes per acre of manure have improved crop establishment and crop yields on saline soil to some extent. Manure increases the organic matter content, enhances soil fertility and improves the physical condition of the soil. This increases moisture storage in the root zone and improves root development.

SUMMARY

Dryland saline seeps are growing both in size and severity across Alberta. When water percolates below the root zone it creates recharge. The result is an increase in groundwater flow, and the deposition of salts in the discharge area. Summerfallow, ponds, reservoirs, borrow pits, and snowfences contribute to recharge.

To determine the cause of the saline seep and locate the "dominant" recharge areas, a Dryland Salinity Investigation Service should be carried out.

To control saline seeps the following practices have proven successful:

- Manage surface accumulations of water in recharge areas

- Reduce summerfallow by adopting longer rotations
- Include deep rooted perennial crops with a high moisture requirement, such as alfalfa, in the rotation. Plant these around and above the affected areas to dry out the subsoil and lower the water table
- Practice snow management to distribute the moisture for crop production
- Plant salt-tolerant grasses in affected areas
- Subsurface drain tiles can be effective in coarse and medium textured saline seeps under proper conditions and
- Eliminate seepage from irrigation canals, dugouts, ponds etc.

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